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REVIEW ARTICLE

Overview of smartphone applications for sleep analysis

Adrian A. Ong*, M. Boyd Gillespie

Medical University of South Carolina, Department of Otolaryngology — Head and Neck Surgery, Charleston, SC, USA

Abstract *Objective:* To review and assess the current selection of sleep analysis smartphone applications (apps) available for download.

Methods: The iOS and Google Play mobile app store were searched for sleep analysis apps targeted for consumer use. Alarm clock, sleep-aid, snoring and sleep-talking recorder, fitness tracker apps, and apps geared towards health professionals were excluded. App information and features were obtained from in-store descriptions, and the app developer website.

Results: A total of 51 unique sleep apps in both iOS and Google Play stores were included. The apps were rated 3.8/5 in both stores, and had an average price of $1.12 in the iOS store and $0.58 in the Google Play store. >65% of sleep apps report on sleep structure, including duration, time awake, and time in light/deep sleep, while reporting of REM was limited. The availability of extra features was variable, ranging from 4% to 73% of apps.

Conclusions: There are a variety of sleep analysis apps with a range of functionality. The apps with the most reviews from the each store are featured. Many apps provide data on sleep structure; however the algorithms are not validated by scientific literature or studies. Since patients may inquire about their sleep habits from these apps, it is necessary for physicians to be aware of the most common apps and the features offered and their limitations in order to properly counsel patients.

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* Corresponding author. Medical University of South Carolina, Department of Otolaryngology — Head and Neck Surgery, 135 Rutledge Avenue, MSC 550, Charleston, SC 29425, USA.
E-mail address: onga@musc.edu (A.A. Ong).

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Introduction

Smartphones have been widely adopted by the general public, and have become an integral part of today's society, including the field of medicine. In addition to mobile communication, smartphones allow consumers to download third-party applications (apps) through an online mobile store. The Apple mobile app store and Google Play (Android) mobile app store has over 1.2 million apps and 1.6 million apps, respectively, and the number of apps continues to grow each year.[1,2] This offers users a variety of apps with a broad range of functions to choose from.

There has been increasing interest among the public in using apps to improve health and fitness, and as a result, the number of apps focused on these issues has grown exponentially. There are over 100,000 health apps combined in the Apple and Google Play mobile app store.[3] These health apps range from weight loss aids to asthma management.[4,5] One target for health and fitness app developers has been sleep and sleep hygiene. These apps have a broad range of functions, including smartalarm clocks, sleep aids, sound recording during sleep, and sleep analysis. Others are developing smartphones programs to aid healthcare professionals in screening patients for habitual snoring and obstructive sleep apnea.[6] Despite increasing usage of health apps by the population, physicians still have limited experience with these apps in clinical practice.

As more consumers adopt sleep apps, physicians should be aware of the available apps, and be able to counsel patients appropriately on sleep app data. The purpose of this study is to review the current selection of apps available for sleep analysis, and to provide a resource to familiarize physicians with the most common sleep apps in current use.

Methods

The Apple (iOS App Store) mobile app store and Google Play mobile app store were searched for sleep analysis apps by one author (A.O.). The following search terms were used: *sleep tracker, sleep apnea, sleep analysis, and sleep cycle*. Sleep analysis apps targeted for consumer use were included. Alarm clock, sleep aid, snoring and sleep talk recorder, and fitness-tracker apps were excluded. In addition, sleep apps for health professionals as well as apps not related to sleep were excluded. Data were collected using store description and the developer's website, including app name, functions, price, date of last update, user rating, number of user reviews, and developer information. Each app store was analyzed separately as some apps were found in both mobile app stores.

Results

The Apple and Google Play mobile app store were searched in mid-June 2015. The search terms yielded a total of 593 and 723 unique apps in the Apple app store and Google Play app store, respectively. A total of 60 apps met the inclusion

criteria, of which 51 were unique. Thirty-three (65%) apps were available in the Apple app store; 27 (53%) in the Google Play store; and 7 (14%) were found in both stores.

The average app price in the Apple store was $1.12, ranging from $0.00 to $9.99, and $0.58 in the Google play store, ranging from $0.00 to $4.49. Twenty (61%) Apple apps and 21 (78%) Google Play apps were free of charge. There were 42 unique developers for the 51 apps. There was minimal information on developers' websites regarding prior experience handling and analyzing medical data.

User ratings/reviews

Ratings were obtained from the mobile app store and had a rating scale of 1–5. Nine (27%) Apple apps and 2 (7%) Google Play apps did not have a rating listed. For the apps with available ratings, the average Apple app rating was 3.8 (range: 2.0–4.7) and the average Google Play app rating was 3.8 (range: 2.7–4.7).

Features

All included apps were evaluated for functionality. Table 1 summarizes percentage of apps that include each feature. All 33 (100%) Apple apps and 27 (100%) Google Play apps report sleep duration, while reporting of sleep structure was more variable. The Apple apps showed the following: 23 (70%) had time spent awake; 21 (64%) had time in light sleep; 23 (70%) had time in deep sleep; and 6 (18%) had time in REM. The Google Play apps had 20 (74%) showing time spent awake; 21 (78%) time in light sleep; 21 (78%) time in deep sleep; and 7 (11%) time in REM. A total of 15 (45%) Apple apps and 19 (70%) Google Play apps calculate sleep efficiency, while 3 (9%) Apple apps and 7 (11%) Google Play apps report sleep debt.

Many apps included features in addition to sleep analysis. Eight (24%) Apple apps and 3 (11%) Google Play apps provide graphs on movement during sleep. Almost half of

Table 1	Number of apps by feature offered.	
	Mobile app store	
	iOS	Android
Sleep Structure		
Duration	33 (100%)	27 (100%)
Awake	23 (70%)	20 (74%)
Light Sleep	21 (64%)	21 (78%)
Deep Sleep	23 (70%)	21 (78%)
REM	6 (18%)	7 (11%)
Sleep Efficiency	15 (45%)	19 (70%)
Sleep Debt	3 (9%)	7 (11%)
Extra Features		
Movement Tracker	8 (24%)	3 (11%)
Sound Recorder	15 (45%)	7 (11%)
Smart Alarm	24 (73%)	15 (56%)
Sleep Aid	9 (27%)	8 (30%)
Notes	12 (36%)	17 (63%)
Heart Rate Monitor	6 (18%)	1 (4%)
Apple Health	11 (33%)	N/A

REM (rapid eye movement).